INFESTATION OF THE PARROTFISH *SPARISOMA CRETENSE* (SCARIDAE) BY THE FISH LOUSE *ANILOCRA PHYSODES* (ISOPODA: CYMOTHOIDAE) IN THE CANARY ISLANDS

by

Dean H. THORSEN (1), Keith J. MILLE (2),
James L. VAN TASSELL (3) & Janos G. HAJAGOS (4)

ABSTRACT. - This study provides evidence that the fish louse, *Anilocra physodes* has inhabited the Island of Gran Canaria in the Canary Archipelago and that it is the only Island in the Archipelago that is infested. Underwater SCUBA visual surveys were conducted on the island of Gran Canaria during the summers of 1993 and 1998, and on the island of Lanzarote (180 km Northwest of Gran Canaria) during the summer of 1993 to characterize the distribution and infestation rates of *A. physodes*, found to parasitize the parrotfish *Sparisoma cretense*. Despite their sympatric distribution throughout the Mediterranean and northeast Atlantic and the broad specificity of *A. physodes*, this is the first documented occurrence of *A. physodes* on a fish of the family Scaridae. Of the 451 *S. cretense* observed on Gran Canaria in 1993, 13.1% were parasitized. On the other hand, no parasites were observed on the 637 parrotfish on Lanzarote. In 1998, of the 904 parrotfish observed on Gran Canaria, 11.5% were parasitized. The most likely factors for the absence of parasitic isopods on Lanzarote include lower host density, greater cleaner fish abundance, limited isopod dispersal, and human intervention.

RÉSUMÉ. - Infestation de *Sparisoma cretense* (Scaridae) par *Anilocra physodes* (Isopoda: Cymothoidae) dans l'archipel des Canaries.

L'étude effectuée dans l'archipel des Canaries révèle que l'anilocre, *Anilocra physodes*, n'infeste que les eaux autour de l'île de la Grande Canarie. Pour établir la répartition et le taux d'infestation par *A. physodes*, des études sous-marines visuelles ont été effectuées autour de la Grande Canarie durant les étés 1993 et 1998, et dans les eaux de Lanzarote (à 180 km au nord-est de la Grande Canarie) durant l'été 1993. Elles ont révélé que *A. physodes* parasite le poisson-perroquet *Sparisoma cretense*. En dépit de la répartition sympatrique à travers la Méditerranée et l'Atlantique nord-est et malgré la large spécificité de *A. physodes*, sa présence sur un Scaridae est ici signalée pour la première fois. Sur 451 individus de *S. cretense* observés en 1993 autour de la Grande Canarie, 13,1% étaient parasités. En revanche, aucun parasite n'a été remarqué sur 637 individus observés dans les eaux de Lanzarote. En 1998, sur 904 individus observés autour de la Grande Canarie, 11,5% étaient parasités. Les facteurs les plus probables qui expliquent l'absence d'isopodes parasites sont: une plus faible densité d'hôtes, une plus grande abondance de poissons nettoyeurs, une faible dispersion des isopodes, et une ingérence humaine limitée.

Key words. - Scaridae - *Sparisoma cretense* - Isopoda - Cymothoidae - *Anilocra physodes* - ASE - Canary Islands - Parasitism - Protandrous hermaphrodites.

---

(1) Florida Museum of Natural History, Fishes, Gainesville, Florida 32611-7800, USA. [deanzool@ufl.edu]

(2) Florida Department of Environmental Protection, Bureau of Beaches and Coastal Systems, 3900 Commonwealth Blvd., M.S. 300, Tallahassee, Florida 32399-3000, USA.

(3) Hofstra University, Biology Department, Hempstead, New York 11550, USA.

(4) State University of New York at Stony Brook, Department of Ecology and Evolution, New York 11794, USA.

Cybium 2000, 24(1): 45-59.

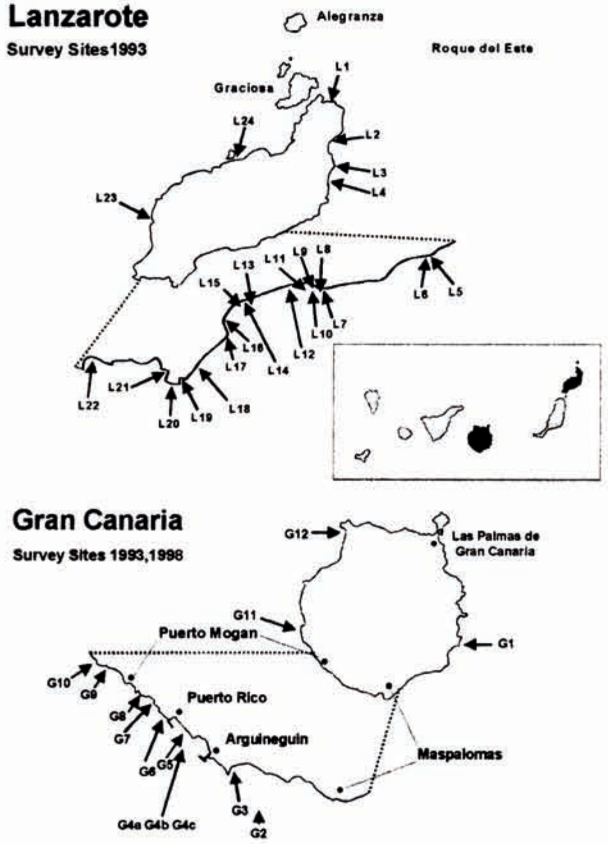

Fig. 1. - Geography of the Canary Islands. Survey sites on Gran Canaria and Lanzarote.

The present study is among the first to examine cymothoids and their respective prevalence through visual surveys. Individuals of *Anilocra physodes* are among the largest fish ectoparasites (TL up to 50 mm or greater), and being conspicuously attached to the exterior, they are well-suited subjects for underwater visual observations. Gran Canaria was surveyed in 1993 and 1998 while Lanzarote was only surveyed in 1993. Gran Canaria was returned to in 1998 to investigate the prevalence of *A. physodes* over the 5 year period, however, we were unable to reach Lanzarote due to lack of funding.

Anilocra physodes (Linnaeus, 1758) is predominantly distributed throughout the Mediterranean (Trilles, 1975), and occurs along the Atlantic coasts of France and Spain, and on the African coast at least as far as Senegal (Thomas Bowman, pers. comm., 1993). The parrotfish *Sparisoma cretense* (Linnaeus, 1758) is distributed throughout the Mediterranean, and occurs from Portugal and the Azores southwards to Senegal (Whitehead *et al.*, 1986). *A. physodes* is most commonly found on fishes of the families Sparidae and Centracanthidae (= Maenidae according to Trilles, 1975). Although *A. physodes* is widely distributed throughout the Mediterranean and Eastern Atlantic, this is the first documented occurrence of *A. physodes* on the fish family Scaridae (*Sparisoma cretense).*

One of us (JVT) began a long-term study of dermersal fish populations of the Canary Islands in July of 1989. He first observed *Anilocra physodes* infesting the parrotfish on Gran Canaria in July of 1992. *A. physodes* has not been observed on El Hierro or Fuerteventura in his studies (unpubl. data, 1990 and 1994, respectively), nor on any other

Table I. - **a**: Survey sites with their respective codes, years sampled, and coordinates. Location coordinates were obtained by GPS; **b**: Survey sites with their respective codes and years sampled. Location coordinates are approximations, GPS not available. O = surveyed; X = not surveyed.

a Site name	Code	1993	Location
Orzola	L1	O	N 29° 13. 921' W 013° 27. 544'
Arrieta	L2	O	N 29° 07. 719' W 013° 27. 544'
Mala	L3	O	N 29° 05. 087' W 013° 26. 863'
La caleta de guatiza	L4	O	N 29° 03. 508' W 013° 27. 648'
Arrecife muelle los puentes	L5	O	N 28° 57. 369' W 013° 32. 451'
Arrecife	L6	O	N 28° 57. 369' W 013° 32. 456'
Punta tiñosa	L7	O	N 28° 55. 087' W 013° 39. 902'
Puerto del carmen	L8	O	N 28° 55. 087' W 013° 40. 392'
Puerto del carmen harbor	L9	O	N 28° 55. 262' W 013° 40. 588'
Puerto del carmen-outside harbor	L10	O	N 28° 55. 262' W 013° 40. 500'
Puerto del carmen obouy	L11	O	N 28° 55. 175' W 013° 40. 784'
Puerto del carmen wrecks	L12	O	N 28° 55. 087' W 013° 41. 176'
Puerto del carmen west	L13	O	N 28° 54. 912' W 013° 42. 451'
Puerto calero harbor	L14	O	N 28° 54. 736' W 013° 42. 941'
Puerto calero west	L15	O	N 28° 54. 473' W 013° 43. 333'
Risco prieto	L16	O	N 28° 53. 245' W 013° 44. 509'
Los haches	L17	O	N 28° 52. 456' W 013° 44. 902'
Punta gorda	L18	O	N 28° 50. 789' W 013° 46. 274'
La juradita	L19	O	N 28° 50. 438' W 013° 46. 666'
Punta de papagayo	L20	O	N 28° 50. 175' W 013° 47. 058'
La santa (boca del abajo)	L21	O	N 28° 50. 350' W 013° 47. 450'
Playa de montaña roja	L22	O	N 28° 51. 579' W 013° 51. 176'
El golfo	L23	O	N 28° 58. 684' W 013° 49. 608'
Roque del este	L24	O	N 29° 07. 193' W 013° 39. 117'

b Site name	Code	1993	1998	Location
Arinaga	G1	O	O	N 27° 52. 433' W 015° 22. 934'
Pasito blanco reef	G2	O	O	N 27° 43. 473' W 015° 37. 457'
Cement factory bay	G3	O	O	N 27° 45. 090' W 015° 40. 048'
Punta del canario reef blocks	G4a	O	O	N 27° 46. 537 W 015° 42. 360'
Punta del canario reef nets	G4b	O	O	N 27° 46. 537 W 015° 42. 360'
Punta del canario reef off	G4c	O	O	N 27° 46. 537 W 015° 42. 360'
Punta del canario	G5	O	O	N 27° 46. 622' W 015° 42. 360'
Puerto rico west	G6	O	O	N 27° 47. 180' W 015° 43. 229'
Punta del los frailes	G7	O	O	N 27° 47. 928' W 015° 44. 362'
Punta cruz de piedra	G8	O	O	N 27° 48. 440' W 015° 45. 007'
Tesarte	G9	O	X	N 27° 52. 088' W 015° 48. 472'
Punta de rabelago	G10	O	X	N 27° 47. 275' W 015° 43. 558'
Punta de las burras	G11	X	O	N 27° 54. 018' W 015° 49. 472'
Sardina	G12	X	O	N 28° 09. 235' W 015° 41. 970'

Table II. - Infestation rates of *Anilocra physodes* per survey site. **a**: Gran Canaria, 1993; **b**: Gran Canaria, 1998. SD = Standard deviation; SCRE = *Sparisoma cretense*.

a Statistic	Type	Total	G1	G2	G3	G4a	G4b	G4c	G5	G6	G7	G8	G9	G10
Number of surveys	Count	414.00	30.00	32.00	47.00	15.00	22.00	18.00	49.00	76.00	35.00	50.00	9.00	31.00
Number of SCRE	Mean	1.08	3.03	0.84	0.04	0.93	1.86	0.22	0.43	1.62	0.51	0.58	1.56	2.10
	SD	2.00	2.47	1.08	0.20	1.16	2.29	0.55	0.91	2.26	1.12	1.79	1.94	3.49
Number of male SCRE	Mean	0.55	1.33	0.41	0.02	0.47	0.95	0.00	0.20	0.76	0.11	0.38	0.78	1.48
	SD	1.28	1.18	0.61	0.15	0.64	1.56	0.00	0.50	1.36	0.40	1.28	1.20	2.77
Number of females SCRE	Mean	0.54	1.70	0.44	0.02	0.47	0.91	0.22	0.22	0.86	0.40	0.20	0.78	0.61
	SD	1.11	1.76	0.67	0.15	0.99	1.38	0.55	0.59	1.33	0.88	0.67	0.97	1.43
Total infested	Percent	13.14	19.78	11.11	0.00	0.00	0.00	0.00	0.00	17.07	33.33	17.24	0.00	9.23
Males infested	Percent	7.52	10.00	15.38	0.00	0.00	0.00	0.00	0.00	10.34	25.00	5.26	0.00	6.52
Females infested	Percent	18.83	27.45	7.14	0.00	0.00	0.00	0.00	0.00	23.08	35.71	40.00	0.00	15.79

b Statistic	Type	Total	G1	G2	G3	G4a	G4b	G4c	G5	G6	G7	G8	G11	G12
Number of surveys	Count	643.00	53.00	52.00	63.00	25.00	23.00	26.00	60.00	69.00	72.00	70.00	62.00	68.00
Number of SCRE	Mean	1.41	3.02	1.15	0.27	0.52	0.39	0.12	0.93	1.41	0.29	1.10	2.58	3.40
	SD	2.45	2.05	1.43	0.60	1.23	0.72	0.33	1.46	2.71	0.74	2.07	3.89	3.46
Number of male SCRE	Mean	0.58	1.25	0.21	0.14	0.12	0.09	0.00	0.38	0.57	0.19	0.61	0.95	1.53
	SD	1.32	1.05	0.41	0.43	0.33	0.42	0.00	0.96	1.45	0.60	1.56	1.82	2.11
Number of females SCRE	Mean	0.83	1.77	0.94	0.13	0.40	0.30	0.12	0.55	0.84	0.10	0.49	1.63	1.87
	SD	1.51	1.48	1.29	0.38	1.22	0.47	0.33	0.79	1.80	0.34	0.90	2.40	2.04
Total infested	Percent	11.50	2.50	1.67	11.76	7.69	0.00	0.00	1.79	18.56	14.29	3.90	8.75	24.68
Males infested	Percent	4.83	1.52	0.00	11.11	33.33	0.00	0.00	0.00	12.82	7.14	0.00	3.39	6.73
Females infested	Percent	16.20	3.19	2.04	12.50	0.00	0.00	0.00	3.03	22.41	28.57	8.82	11.88	39.37

of the Canary Islands except Gran Canaria (Alejandro Baez-Acosta, pers. comm., 1999) to this date, 1999.

Isopods of the family Cymothoidae, commonly called fish lice, are well documented as ectoparasites of fish (Legrand, 1952; Brusca, 1981; Williams, 1984). They are protandrous hermaphrodites, with a free-swimming male undergoing a transformation, at some critical point, into a sedentary female (Legrand, 1952). The cymothoids are blood-sucking parasites that are metabolically dependent upon their host. In some studies isopods have been shown to have little or no effect on their host aside from a small puncture wound at the site of attachment (Brusca, 1981). Other studies have shown that *Anilocra* injury can vary from small-localized sores to erosion of scales and epidermal layers (Bashirullah, 1991). Marine cymothoids are almost exclusively inhabitants of shallow water, few being known from bathypelagic or greater depths (Brusca, 1981). Infesting demersal to semi-pelagic schooling coastal marine fishes, their distribution is often patchy (Brusca, 1981). *A. physodes*, located on the external epidermal surfaces of its host, is considered to have a broad ecological specificity (tied to regiment or potential of infestation) rather than a phylogenetic based host specificity as suggested for other Cymothoidae isopods (Trilles, 1964a). The distribution of isopods is usually dependent upon the number of host species they infest (Brusca, 1981) and by the movement of hosts containing parasites (Kennedy, 1976).

METHODS

Sample locations were chosen on the Island of Gran Canaria (total of 12 sites) and Lanzarote (total of 24 sites) to include a variety of accessible near shore habitats with distances varying from 5 to 500 m from shore. Survey sites on Gran Canaria ranged from rocky sub-tidal zones to sandy habitats, with depths varying from 5 to 20 m. The survey sites on Lanzarote were considerably rockier with depths ranging from 5 to 45 m. Temperature on both islands was 22°C ± 2°C during the sampling periods. Maps showing the survey sites on Gran Canaria (1993, 1998) and Lanzarote (1993) are shown in figure 1, and the site codes are given in table I.

The Point-count visual survey technique (Bortone *et al.*, 1989; Bortone *et al.*, 1991) was used in this study to estimate the dermersal fish population and corresponding parasite infestation rates. The Point-count visual survey method has been used in previous studies in the Canary Islands (Mille and Van Tassell, 1994; Bortone *et al.*, 1994; Falcón *et al.*, 1996) and can be done accurately with training and practice (Bortone *et al.*, 1992). The survey technique is straightforward: a diver kneels at the center of a circle having a 5.64 m radius (100 m^2), using a weighted line to estimate the radius. A diver turns slowly and records all the species inside the circle over a 5-min period. The size (TL, in cm) of each fish within the survey area was recorded. This technique may be more accurate than fish catch data since *Anilocra physodes* may detach itself from its host when caught and removed from the water (Keusink, 1979). Unlike commercial catches, visual surveys do not disturb the environment and the isopods remain on their respective host. Williams (1984) collected isopod infestation data based on *in situ* observations, similar to the methods used here, and found reliable results.

In 1993, 414 surveys (41,400 m^2) were conducted on Gran Canaria (July 1-13) and 850 surveys (85,000 m^2) were conducted (July 20-August 17) on the island of Lanzarote. In 1998, 643 surveys (64,800 m^2) were conducted on Gran Canaria (July 1-August 6). The numbers of surveys per site are shown in table II.

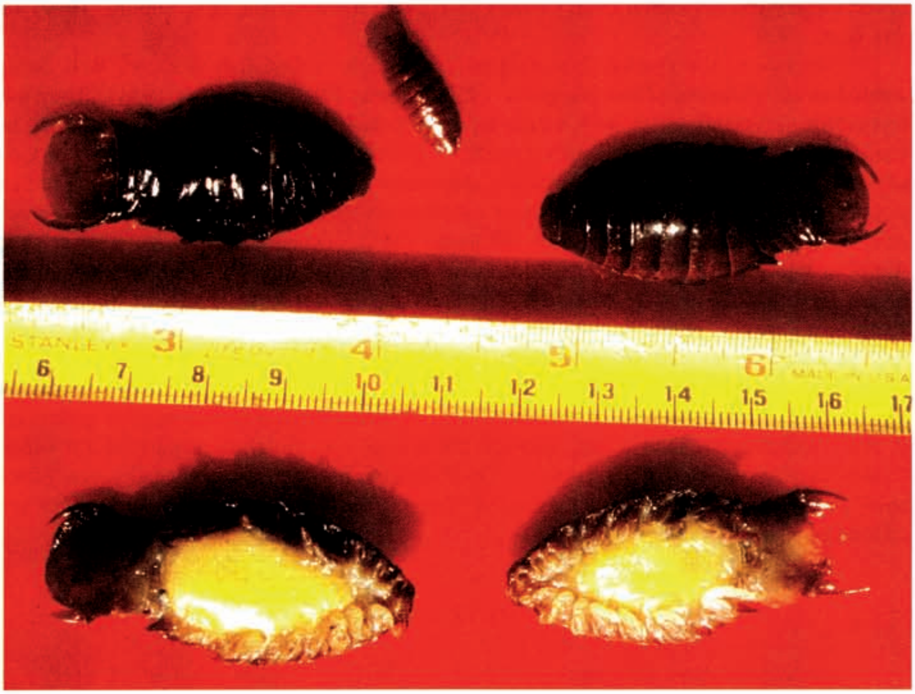

Fig. 2. - *Anilocra physodes* specimens collected from *Sparisoma cretense* on Gran Canaria.

With visibility in the Canary Islands ranging from 15 to 30 m horizontally, the adult parasites were readily visible on the host. The smallest of isopods could have been overlooked during a survey. Therefore, this method most likely represents an underestimation of the parasite abundance. The above discrepancy in the data collection, however, is of major concern only when discussing the absolute parasite abundance and distribution. If one assumes consistency in the data collection, the relative rates of infestation should be unaffected by a slight underestimation due to sampling error.

When recording the parrotfish, only the number of infested fish were recorded, not the number of parasites on them. This procedure was chosen to simplify the method in which divers collected data. The parasites (commonly 1-2 parasites per parasitized fish) were always observed with their head facing towards the anterior. This agrees with previous studies (Trilles, 1965; Korner, 1982).

Apparently, the European parrotfish is the only species where the males are grey and the females are a conspicuous red and yellow (Wirtz, 1994). We do not believe the wide color variation between males and females is a factor in diver observation of the isopods. The isopods large size (TL up to 50 mm or greater), along with the slow moving bottom feeding behavior of the parrotfish (Wirtz, 1994), offered sufficient opportunities during a survey to observe the presence of parasites on both sexes.

Samples of *Anilocra physodes* (Fig. 2) were obtained from fisherman in Arguineguin on Gran Canaria in 1993 and 1998. They were fixed in 10% formalin and later transferred to 70% ethyl alcohol. Isopods were identified by using Trilles (1965), and Korner

Table III. - Single classification ANOVA per survey with location as a factor. **a**: Gran Canaria, 1993; **b**: Gran Canaria, 1998. DF = degrees of freedom; Σ^2 = sum squared; X = mean squared; Significant codes: *** = 0; ** = 0.001; * = 0.01.

a	**DF**	Σ^2	**X**	**F**	**Pr (> F)**	**G1**	**G2**	**G3**	**G4a**	**G4b**	**G4c**	**G5**	**G6**	**G7**	**G8**	**G9**	**G10**
Total fish	11	294.520	26.770	7.882	1.950e-12***	3.033	0.843	0.042	0.933	1.863	0.222	0.428	1.618	0.514	0.580	1.555	2.096
Total fish parasitized	11	11.166	1.105	3.202	0.0003***	0.600	0.093	0.000	0.000	0.000	0.000	0.000	0.276	0.171	0.100	0.000	0.193
Total males	11	86.260	7.840	5.357	6.007e-08***	1.333	0.406	0.021	0.466	0.954	0.000	0.204	0.078	0.763	0.380	0.777	1.483
Total males parasitized	11	0.772	0.070	1.311	0.215	0.133	0.062	0.000	0.000	0.000	0.000	0.000	0.078	0.028	0.020	0.096	0.000
Total females	11	77.820	7.070	6.597	3.721e-10***	1.700	0.437	0.021	0.466	0.909	0.222	0.224	0.855	0.400	0.200	0.777	0.612
Total females parasitized	11	6.589	0.599	3.291	0.0002427***	0.466	0.031	0.000	0.000	0.000	0.000	0.000	0.197	0.142	0.080	0.000	0.096

b	**DF**	Σ^2	**X**	**F**	**Pr (> F)**	**G1**	**G2**	**G3**	**G4a**	**G4b**	**G4c**	**G5**	**G6**	**G7**	**G8**	**G11**	**G12**
Total fish	11	1229.200	111.700	19.852	< 2.2e-16***	4.441	1.153	0.269	0.520	0.391	0.115	0.933	1.405	0.291	1.100	2.580	3.352
Total fish parasitized	11	39.827	3.621	15.214	< 2.2e-16***	0.058	0.019	0.031	0.040	0.000	0.000	0.016	0.260	0.041	0.042	0.225	0.838
Total males	11	220.380	20.030	11.245	< 2.2-16***	1.838	0.211	0.142	0.120	0.086	0.000	0.383	0.565	0.194	0.614	0.951	1.485
Total males parasitized	11	0.739	0.067	2.589	0.003156**	0.014	0.000	0.015	0.040	0.000	0.000	0.000	0.072	0.013	0.000	0.032	0.102
Total females	11	427.270	38.840	17.773	< 2.2e-16***	2.602	0.942	0.126	0.400	0.304	0.115	0.550	0.840	0.097	0.485	1.629	1.867
Total females parasitized	11	30.665	2.788	13.041	< 2.2e-16***	0.044	0.019	0.015	0.000	0.000	0.000	0.016	0.188	0.27	0.042	0.193	0.735

(1982) and were later confirmed to be *A. physodes* by Dr. Bowman at the United States National Museum in Washington D.C. in 1993.

Contingency tables (Sokal and Rolf, 1995) were constructed to test if the frequency of infested versus non-infested parrotfish by the isopod, *A. physodes*, was statistically independent of several factors (Table III). An exact test of independence was made using RxC (Miller, 1997) a program implementing the metropolis algorithm (Raymond and Rousset, 1995). The following contingency tables were constructed: location as a factor for Gran Canaria 1993 and 1998, year on Gran Canaria as a factor, and sex as a factor.

Analysis of variance was used to test the significance of the means shown in table IV. ANOVA models were also constructed to test if significant differences in numeric abundance existed for the cleaner fishes *Coris julis* and *Thalassoma pavo* across islands and years.

RESULTS

The infestation rates of *Anilocra physodes* on Gran Canaria per survey site exhibited a patchy distribution varying spatially in 1993 and 1998 (Table II, Fig. 3, p = 0.0889). In 1993 the highest infestation rates were at Arinaga (G1) 19.7%, Puerto Rico West (G6) 17.0%, Punta Del Las Frailes (G7) 33.3%, and Punta Piedra (G8) 17.2% (p = 0.0028). In 1998 the highest infestation rates were located at Puerto Rico West (G6) 18.5%, Punta Del Los Frailes (G7) 14.3%, and Sardina (G12) 24.6% (Table II, p = 0.00).

From 1993 to 1998 the infestation rates at Puerto Rico West (G6) were 17.7 and 18.6%, respectively. Cement Factory Bay (G3) increased from 0 to 11.8% in 1993 and 1998, respectively; however, the infestation rate decreased at Arinaga (G1) from 19.8 to 2.5%, Pasito Blanco Reef (G2) from 11.1 to 1.7%, Punta Del Los Frailes (G7) from 33.3 to 14.3%, and Punta Peidra (G8) from 17.2 to 3.9% in 1993 and 1998, respectively (Table II).

In 1993, 451 parrotfish were observed on Gran Canaria, of those, 59 (13.1%) were infested with one or more isopods. Male and female host infestation rates varied depending on the survey site from 0 to 25% and 0 to 40%, respectively (Table IIa, p = 0.00). Of the 637 parrotfish observed on Lanzarote, none were infested (0%). In 1998, of 904 parrotfish observed on Gran Canaria, 104 (11.5%) were infested with one or more

Table IV. - Single classification ANOVA with year and island as a factor for both *Coris julis* and *Thalassoma pavo*. Significant codes: *** = 0; ** = 0.001; * = 0.01.

	Lanzarote 1993				Gran Canaria 1993				
Species	**Mean**	**S D**	**Abundance**	**Occurrence**	**Mean**	**S D**	**Abundance**	**Occurrence**	
C. julis	1.20	3.44	48	34.76	0.69	4.48	65	14.79	
T. pavo	10.05	15.17	130	88.62	5.79	9.80	100	76.26	
	Gran Canaria 1998				**Analysis**				
Species	**Mean**	**S D**	**Abundance**	**Occurrence**	**DF**	Σ^2	**X**	**F**	**Pr (> F)**
C. julis	0.020	0.18	2	1.87	2	371.5	185.7	21.689	5.44e-10***
T. pavo	4.862	8.86	81	54.59	2	26187.0	13093.0	122.000	< 2.2e-16***

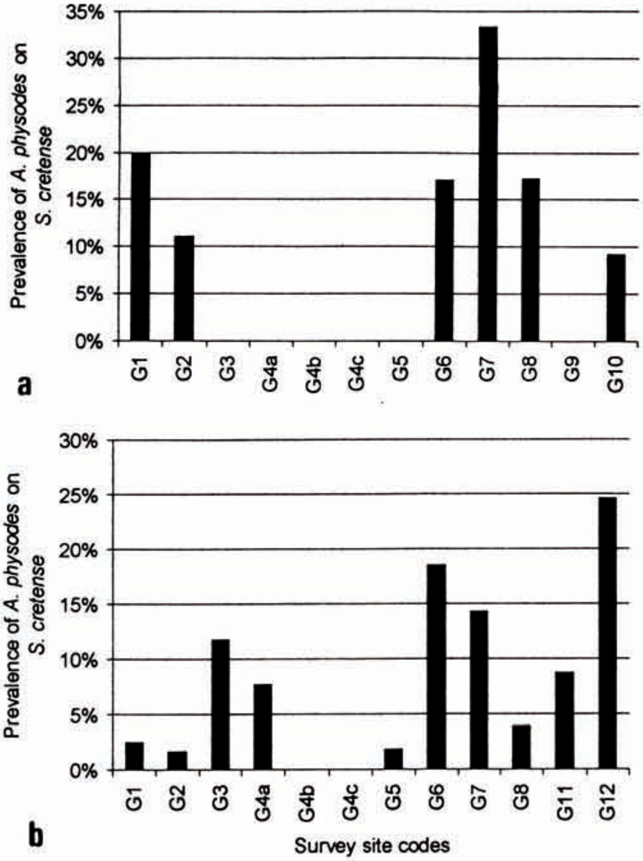

Fig. 3. - Infestation rates of *Anilocra physodes* per survey site. **a**: Gran Canaria, 1993; **b**: Gran Canaria, 1998.

isopods. Male and female infestation rates varied by survey site from 0 to 33.3% and 0% to 39.4%, respectively (Table IIb, p = 0.00). Female parrotfish are more likely to be infested by *A. physodes* than male parrotfish (Table III).

The size class distribution of the parrotfish populations from the two Islands is shown in figure 4. The mean sizes were 22 and 23 cm for Gran Canaria and Lanzarote, respectively. Since each survey represents a given area (100 m^2), the average parrotfish densities were calculated to be 1.25 and 0.75 fish per 100 m^2 on Gran Canaria and Lanzarote, respectively. Gran Canaria's parrotfish density being 1.67 times that of Lanzarote.

Cleaner fish have been documented in the Canary Islands by Van Tassell *et al.* (1994). Both *Coris julis* and *Thalassoma pavo* have been observed as cleaners of the parrotfish in the Canary Islands. Lanzarote's cleaner fish population, when looked at cleaners/survey, is about twice that of Gran Canaria (Table V). On Gran Canaria in 1993, the mean number/survey of *C. julis* was 0.69 (286 total individuals observed, TI) and 5.79 (2397 TI) for *T. pavo*. In 1993 on Lanzarote, the mean number/survey of *C. julis* was 1.2

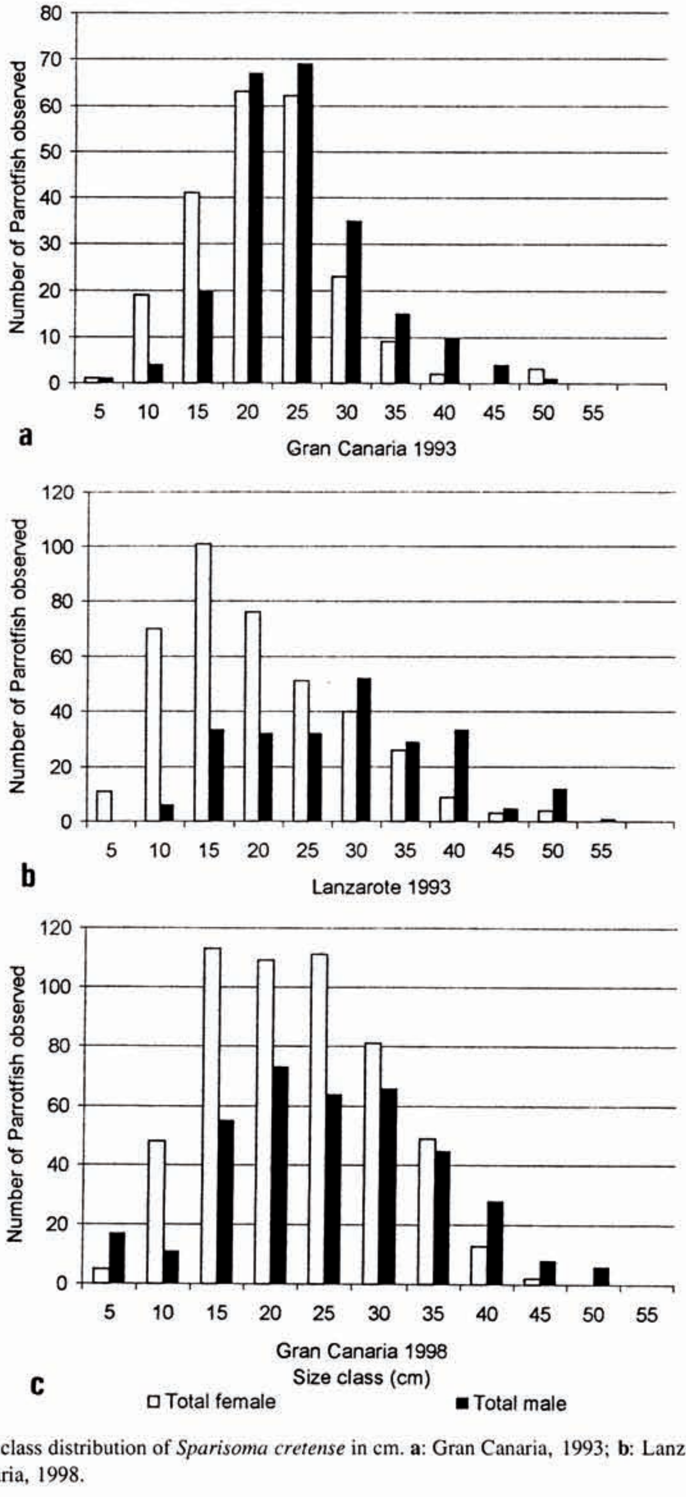

Fig. 4. - Size class distribution of *Sparisoma cretense* in cm. **a**: Gran Canaria, 1993; **b**: Lanzarote, 1993; **c**: Gran Canaria, 1998.

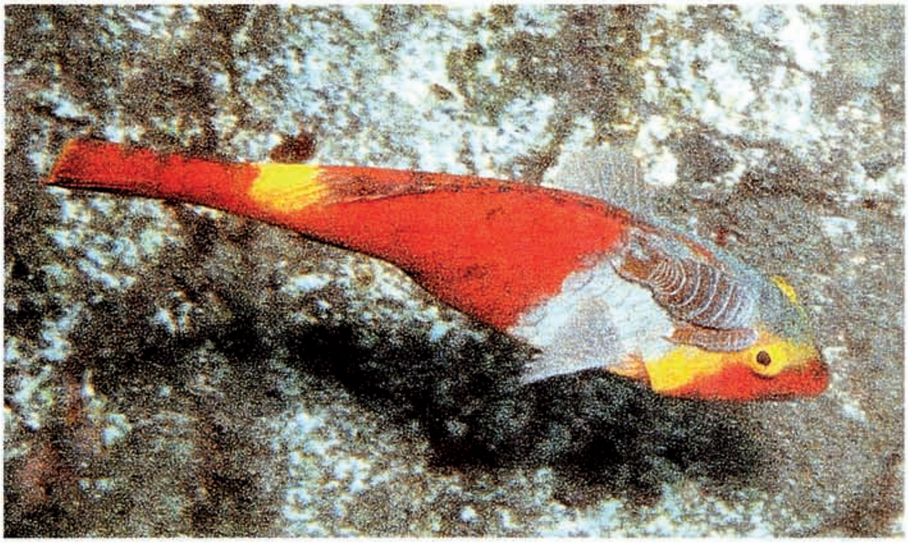

Fig. 5. - Underwater photographs of *Sparisoma cretense* with *Anilocra physodes* positioned on the dorsal axial musculature mass. Notice pairing of male and female isopods.

(1020 TI) and 10.05 (8543 TI) for *T. pavo*. On Gran Canaria in 1998, the mean number/survey of *C. julis* was 0.02 (13 TI) and 4.86 (3149 TI) for *T. pavo*. There were statistical significant differences in the mean abundance across islands and years (Table IV) for both *C. julis* and *T. pavo*.

We observed *Anilocra physodes* positioned on the dorsal axial musculature mass of the parrotfish (Fig. 5). *A. physodes* has been documented to be on various positions on its host fish (Trilles, 1964a), though we only observed them in this position. This, however, may be a result of *A. physodes* exhibiting topic selectivity as seen with other Cymothoidae isopods (Rokicki and Wrzesinski, 1984).

While conducting visual surveys on Gran Canaria, we observed *Anilocra physodes* infesting *Ophioblennius atlanticus* (1.9%, 51 TI), *Pseudocaranx dentex* (1.7%, 58 TI),

Table V. - Cleaner fish data for Gran Canaria, 1993, Lanzarote, 1993, and Gran Canaria, 1998. SD = Standard deviation; Mean = mean per survey; Abundance = maximum abundance per survey; Occurrence = percent occurrence per survey.

	Mean	**SD**	**Abundance**	**Occurrence**
Gran Canaria 1993				
Coris julis	0.69	4.48	65	14.79
Thalassoma pavo	5.79	9.80	100	76.26
Lanzarote 1993				
Coris julis	1.20	3.44	48	34.76
Thalassoma pavo	10.05	15.17	130	88.62
Gran Canaria 1998				
Coris julis	0.02	0.18	2	1.87
Thalassoma pavo	4.86	8.86	81	54.59

Sarpa salpa (0.2%, 589 TI), *Spondylisoma cantharus* (0.9%, 233 TI), and *Synodus synodus* (0.8%, 129 TI) in the summer of 1998 (Table VI). This is compared to the 13.1 and 11.5% infestation of the parrotfish in 1993 and 1998, respectively. Trilles (1964a) documented the ubiquitous nature of *A. physodes* and therefore, it is not surprising to find the isopods on these fishes. The low percentages shown above, for all fish except *Sparisoma cretense*, would probably not have been detected as host species but for the large number of surveys conducted. This is consistent with a study conducted by Nieto and Alberto (1994) with *Anilocra frontalis*.

DISCUSSION

The isopod infestation rate of *Sparisoma cretense* by *Anilocra physodes* was significantly higher on Gran Canaria in 1993 and 1998, (13.1 and 11.5% respectively), than on Lanzarote in 1993 (0%) (Tables II, III). Some factors that could attribute to the absence of parasitic isopods on Lanzarote include lower host density, greater cleaner abundance, and the limited ability of the isopods to disperse, and human intervention.

Legrand (1952) describes juvenile *A. physodes* as "randomly somersaulting" through the water, ventral side up. *A. physodes* needs to attach to a host, reproduce, and then their offspring need to infest other hosts. One would expect that a fish population with a high density would have a greater chance of infestation due to *A. physodes* behavior. *A. physodes* may require a parrotfish population of that exhibited on Gran Canaria (1.25 and 0.75 fish per 100 m^2 on Gran Canaria and Lanzarote, respectively) to maintain its population. However, the island of El Hierro has a larger parrotfish population than Gran Canaria along with a larger cleaner fish population (Bortone *et al.*, 1991) and no parrotfish infestation by *A. physodes* (unpubl. data, 1994). When you look at Gran Canaria on the whole, it contains a large parrotfish density and the smallest cleaner fish population of all the islands surveyed. This combination may have allowed *A. physodes* to establish a population on Gran Canaria.

Another possibility is that *A. physodes* was transported by an intermediate host to Gran Canaria. Previous studies conducted on *Anilocra abudefdufi*, *A. acanthuri*, *A. chaetodontis*, *A. chromis*, *A. haemuli*, *A. holocentri*, *A. holacanthi*, *A. myripristis*, and *A. partiti* in the Caribbean have documented intermediate hosts (Williams, 1984). These hosts are used by male isopods while they maintain their free-swimming ability. They may swim from host to host mating with multiple adult females and/or move to an uninfected final host to develop into a female (Williams, 1984). Isopods moving from host to host may therefore be carried to different locations before settling down on their final host. Williams (1984) noted that the life cycle strategies of the Caribbean *Anilocra* species differ from other cymothoid genera and other species of *Anilocra*. Most cymothoids and other *Anilocra* have a large, static, monogamous, developmentally stunted male

Species	N	P	PV
Ophioblennius atlanticus	51	1	1.93
Pseudocaranx dentex	58	1	1.70
Sarpa salpa	589	1	0.17
Spondylisoma cantharus	233	2	0.86
Synnodus synodus	129	1	0.77

Table VI. - Fish species infested by *Anilocra physodes* in 1998 on Gran Canaria. N = specimens observed; P = parasitized specimens; PV = percentage of parasitism.

(Williams, 1984). The male of the Caribbean *Anilocra* species is functional at a body size and stage of morphological development typical of juveniles of these other cymothoids, and is highly motile, potentially polygamous, and developmentally unrestricted. It is referred to as a "micromale" (Williams, 1984). However, unlike the Caribbean *Anilocra* species, *A. physodes* lose its free-swimming ability at an early age (Trilles, 1964b) and may not exhibit any "micromale" stage. This short free-swimming stage for *A. physodes* in the Canary Islands would make an intermediate host unlikely. In addition, *A. physodes* for the most part infests shore fishes, thus transport to the Canary Islands via intermediate host is unlikely. If an intermediate host did transport *A. physodes* to Gran Canaria, there is no reason why it would not have transported it to additional islands in the Archipelago.

Adult *A. physodes* could infest the Islands if they were attached to a permanent host. Typical hosts for *A. physodes* include the families Sparidae (Porgies), Merlucciidae (Whiting, Silver Hakes), Centracanthidae (Snapper-Mullets), Clupeidae (Herrings), Gadidae (Cods) (Trilles, 1964a) and Scaridae (Parrotfishes, present study) (Table VII). Hosts for *A. physodes* tend to be shore fishes that do not disperse large distances, except for Gadidae and Clupeidae. If *A. physodes* was dispersed via a host, Lanzarote, due to its geographic position would most likely become the first infested Island. This however is not the case. Gran Canaria, situated in the middle of the Canary Islands, is the only Island infested.

Each year, vessels transport hundreds of millions of tons of ballast water around the world. The water and associated sediments contain hundreds of species of organisms, of which many have become established in new habitats and caused negative effects to human health, economy and the environment (Gauthier and Steel, 1996). Dispersal through ballast water discharges has been documented for many species (Hensley, 1993; Mills *et al.*, 1996). With large numbers of commercial vessels going to and from the

Table VII. - Hosts for *Anilocra physodes*. * = In Canaries and Mediterranean; ** = Only in Canaries, Azores.

Centracanthidae	**Clupeidae**	**Gadidae**	**Merlucciidae**	**Sparidae**
Centracanthus cirrus *	_Sardinella aurita_ *	_Gaidropsarus guttatus_ **	_Merluccius merluccius_ *	_Boops boops_ *
	Sardinella maderensis *	_Gaidropsarus granti_ **		_Diplodus cervinus_ *
	Sardina pilchardus *	_Phycis phycis_ *		_Diplodus puntazzo_ *
				Dentex gibbosus *
				Diplodus sargus *
				Diplodus vulgaris *
				Lithognathus mormyrus **
				Oblada melanura
				Pagellus acarne **
				Pagellus erythrinus
				Pagrus auriga
				Pagrus pagrus **
				Sarpa salpa
				Sparus aurata
				Spondylisoma cantharus **

Canary Islands, the possibility exists that ballast water containing free-swimming juvenile *A. physodes* could have been discharged on Gran Canaria.

There has been considerable destruction to the habitat in the Canary Islands due to an increase in tourism, construction along the coast, and increased fishing pressure. Survey data taken on Lanzarote from 1990 to 1993 shows a decline in the parrotfish population (unpubl. data, 1993); this is when *A. physodes* was only first observed on Gran Canaria. The decline in the fish population might make it impossible for *A. physodes* to establish a population on Lanzarote. However, Lanzarote still maintains a larger cleaner fish population than Gran Canaria, thus preventing the isopods from inhabiting that island and infesting the parrotfish.

In conclusion, the data collected from the Canary Islands generally corresponds to that of the literature, but represents the first time that *A. physodes* has been recorded on the parrotfish. Differences in parasite abundance between Gran Canaria and Lanzarote may reflect differences in the fish community structure and deserves further study. Perhaps data collected from other islands would help shed further light on this hypothesis.

Acknowledgments. - We would like to thank Top Diving (August and Marline de Vylder) who provided us with free air fills and other help required for diving while on Gran Canaria. Thanks to the Puerto Rico Harbor for free boat dockage during our research and to Gay Oulton for coordinating local logistics. We thank Dr. Thomas Bowman (USNM) for identification of the isopods and providing reprints. Thanks also to Stephan Lensch for the underwater photos of the Parrotfish with isopods and French translation. Thanks also to Gail Insler (Adelphi University), James Albert (Florida Museum of Natural History), and John Maniscalco for comments on the MS. This study was funded in part by EARTHWATCH and its Research Corps in 1993.

REFERENCES

BASHIRULLAH A.M.K., 1991. - Occurrence and site specificity of an isopod *Anilocra laticauda* H. Milne Edwards, 1840 (Isopoda, Cymothoidea) parasitic on the grunt, *Orthopristis ruber* (Cuvier) in Eastern Venezuela. *Crustaceana*, 61(1): 38-42.

BORTONE S.A., KIMMEL J.J. & C.M. BUNDRICK, 1989. - A comparison of three methods for visually assessing reef communities: Time and area compensated. *Northeast Gulf Sci.*, 10(2): 85-96.

BORTONE S.A., VAN TASSELL J., BRITO A., FALCÓN J.M. & C.M. BUNDRICK, 1991. - A visual assessment of the inshore fishes and fishery resources of El Hierro, Canary Islands: A baseline survey. *Ciencias Mar.*, 55: 529-541.

BORTONE S.A., VAN TASSELL J., BRITO A., FALCÓN J.M. & C.M. BUNDRICK, 1992. - Visual census as a means to estimate standing biomass, length, and growth in fishes. *Proc. Am. Acad. Underw. Sci., Diving for Science*, 12: 13-21.

BORTONE S.A., VAN TASSELL J.L., BRITO A. & C.M. MENA, 1994. - Enhancement of the near shore fish assemblage in the Canary Islands with artificial habitats. *Bull. Mar. Sci.*, 55(2-3): 602-608.

BRUSCA R., 1981. - A monograph on the isopoda Cymothoidae (Crustacea) of the eastern Pacific. *Zool. J. Linn. Soc.* 73: 117-199.

FALCÓN J.M., BORTONE S.A., BRITO A. & C.M. BUNDRICK, 1996. - Structure of and relationships within and between the littoral, rock-substrate fish communities off four islands in the Canarian Archipelago. *Mar. Biol.*, 125: 215-231.

GAUTHIER D. & D.A. STEEL, 1996. - A synopsis of the situation regarding the introduction of nonindigenous species by ship-transported ballast water in Canada and selected countries. *Can. Manuscript Rep. Fish. Aquat. Sci.*, 63 p.

HENSLEY D.A., 1993. - Two new flatfish records from the Red Sea, an Indo-Pacific samarid (*Samariscus inornatus*) and the European plaice (*Pleuronectes platessa*). *Isr. J. Zool.*, 39(4): 371-379.

KENNEDY C.R., 1976. - Reproduction and dispersal. *In:* Ecological Aspects of Parasitology (Kennedy C.R., ed.). Amsterdam: North-Hollands Publ.

KEUSINK C. 1979. - Biology and natural history of the fish parasite *Lironeca vulgaris*. Masters Thesis, 66 p. San Jose State Univ.

KORNER H.K., 1982. - Countershading by physiological colour change in the fish louse *Anilocra physodes* L. (Crustacea: Isopoda). *Oecologia*, 55: 248-250.

LEGRAND J.J., 1952. - Contribution à l'étude expérimentale et statistique de la biologie d'*Anilocra physodes* L. (Crustacé isopode cymothoidé). *Arch. Zool. Exp. Gén.*, 89: 1-56.

MILLE K.J. & J.L. VAN TASSELL, 1994. - Diver accuracy in estimating length of models of the parrotfish, *Sparisoma cretense*, in situ. *Northeast Gulf Sci.*, 13(2): 149-155.

MILLER M.P., 1997. - RxC, a program for the analysis of contingency table. Software distributed by the author. [http://herb.bio.nau.edu/~miller]

MILLS E.L., STARYER D.L., SCHEUERELL M.D. & J.T. CARLTON, 1996. - Exotic species in the Hudson River basin: A history of invasions and introductions. *Estuaries*, 19(4): 814-823.

NIETO P. & L.J. ALBERTO, 1994. - Presence of *Anilocra frontalis* H. Milne Edwards, 1840 (Isopoda, Flabellifera) on the southern Atlantic coast of the Iberian Peninsula: Spectrum of parasitism and parasitic relationship with *Gobius paganellus* Linnaeus, 1758 (Pisces, Gobiidae). *Crustaceana*, 66(1): 67-77.

ROKICKI J. & O. WRZESINSKI, 1984. - External injuries of fish caused by parasitic isopods and some predatory fish. *Wiadomosci Parazyt.*, 30(2): 229-240.

RAYMOND M.L. & F. ROUSSET, 1995. - An exact test for population differenciation. *Evolution*, 49: 1280-1283.

SOKAL R. & F.J. ROLF, 1995. - Biometry. 3rd edition, 887 p. New York: W.H. Freeman.

TRILLES J.P., 1964a. - Spécificité parasitaire chez les isopodes Cymothoidae méditerranéens. Note préliminaire. *Vie Milieu*, 15(1): 105-116

TRILLES J.P., 1964b. - À propos d'un fait particulier d'éthologie parasitaire chez les Isopodes Cymothoidae: la relation de taille entre parasites et poissons. Note préliminaire. *Vie Milieu*, 15: 365-369.

TRILLES J.P., 1965. - Sur deux espèces d'Anilocres (Isopodes, Cymothoidae) mal connues: *Anilocra physodes* (L.) et *Anilocra frontalis* (Milne Edwards). *Ann. Parasitol.*, 40(5): 575-594.

TRILLES J.P., 1975. - Les Cymothoidae (Isopoda, Flabellifera) des côtes françaises. II. Les Anilocridae Schioedte et Meinert, 1881. Genres *Anilocra* Leach, 1818 et *Nerocila* Leach, 1818. *Bull. Mus. natl. Hist. nat., Paris, Zool.*, 200: 303-345.

VAN TASSELL J.L., BRITO A. & S.A. BORTONE, 1994. - Cleaning behavior among marine fishes and invertebrates in the Canary Islands. *Cybium*, 18(2): 117-127.

WHITEHEAD P.J.P., BAUCHOT M.-L., HUREAU J.-C., NIELSEN J. & E. TORTONESE, 1986. - Fishes of the North-eastern Atlantic and the Mediterranean. 3 vols, 1007 p. Paris: UNESCO.

WILLIAMS L.B., 1984. - Geographic distribution and early life history of *Anilocra* (Isopoda: Cymothoidae) parasites of Caribbean coral reef fishes. Ph.D. thesis, 141 p. Auburn Univ., USA.

WIRTZ P., 1994. - Underwater Guide: Madeira-Canary Islands-Azores. 159 p. Stuttgart: Naglschaid.

Reçu le 27.10.1998.
Accepté pour publication le 28.10.1999.